Alpine Entomology 9 2025, 51–63 | DOI 10.3897/alpento.9.158239

PENSOFT

Alpine Entomology

The supposedly unmistakable mistaken: *Carcina ingridmariae* sp. nov., a surprising example of overlooked diversity from Europe and the Near East (Lepidoptera, Peleopodidae)

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https://zoobank.org/D13A9858-2020-4BD3-A06C-D955C6D01371

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Academic editor: Bernard Landry ♦ **Received** 7 May 2025 ♦ **Accepted** 14 July 2025 ♦ **Published** 31 July 2025

Abstract

Carcina ingridmariae **sp. nov.** is described from the eastern Mediterranean region (Greece, Croatia, Cyprus, Türkiye). The species differs strikingly from the so far only representative of the genus in the Western Palearctic, *C. quercana* (Fabricius, 1775), in the DNA barcode and the male and female genitalia, but less conspicuously in habitual characteristics. All diagnostically relevant characters are figured and discussed. The usefulness of comprehensive genetic inventories for recognizing species that have been inadequately considered because they are regarded as unmistakable is discussed.

Key Words

DNA barcoding, Gelechioidea, integrative taxonomy, Mediterranean, misidentification

Introduction

Carcina quercana (Fabricius, 1775) is one of the best known micromoths in Europe and has always been considered easy to identify due to its distinctive external features. The species even adorns the cover of a popular identification book (Sterling and Parsons 2012). Due to its striking appearance, it was historically described by only a few authors under different names, the last valid one about 150 years ago (Millière, 1874).

The history of the supra-generic classification appears to be much more complex and *C. quercana* has been classified in different families and subfamilies (all belonging to Gelechioidea) and even today the final systematic placement does not seem to be fixed. Originally described as *Pyralis* (and junior synonyms in *Tortrix* and *Tinea*), *C. quercana* was long classified in the family Oecophoridae, or even in its own family Carcinidae (Leraut 1992; Kaila 2004) which, however, is a homonym of Carcinidae in Decapoda (Nieukerken et al. 2011). More recently the taxon was placed in the Depressariidae or Elachistidae (as Peleopodinae) (Hannemann 1991; Kaila et al. 2011; Lvovsky 2012; Heikkilä et al 2013). Currently, there is a broader consensus on assignment of *Carcina* to the family Peleopodidae (Nieukerken et al. 2011; Sterling and Parsons 2012; Wang and Li 2019; Buchner and Corley 2024; Bánki et al. 2025), though the genus was not analysed in extensive modern phylogenies of Lepidoptera in general and Gelechioidea in particular (Regier et al. 2013; Sohn et al. 2015). On the other hand, a little-noticed recent study that considers both morphology and molecular data assigns *Carcina* as part of the Oecophoridae *sensu lato* and points preferably to a status as a separate family (Ponomarenko and Chernikova 2018).

Peleopodidae was introduced by Hodges (1974) and according to Nieukerken et al. (2011) it includes 28 species in 7 genera. Following more recent studies 202 species in 11 genera belong to the family, with only 4 genera and 15 species assigned to Peleopodinae (Wand and Li 2019; Bánki et al. 2025). Only two representatives of the genus *Carcina* Hübner, 1825 are currently accepted, with *C. quercana* as the type species

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and a second species, *Carcina haemographa* Meyrick, 1937, described from the Democratic Republic of the Congo (Meyrick 1937) (Bánki et al. 2025). However, the species described from the Far East as *Lecithocera luridella* (Christoph 1882) also clearly belongs to *Carcina* after examination of the genital structures (Ponomarenko and Chernikova 2018).

Although the phylogenetic relationships of *Carcina* still appear to be unsatisfactorily clarified, the specific delimitation of *C. quercana* was previously considered to be completely unproblematic. Only extensive genetic surveys of the lepidopteran fauna of Greece indicated a striking range of variation in DNA barcode sequences initially interpreted to be intraspecific (Huemer and Mutanen 2022). It was only in the context of the study of the Lepidoptera of Crete (Huemer et al. 2025) that greater attention was paid to this problem. A genital morphological analysis led to the discovery of a clearly separated new species which is described in the present work.

Material and methods

The study is based on c. 100 specimens of *Carcina***.** The material was pinned, dried, and either traditionally set or spread. The forewing length of the new species was measured from the wing base to the apex (including fringe scales) using an ocular micrometer. Male and female genitalia were dissected and prepared using standard methods for microlepidoptera (Robinson 1976).

DNA tissue samples (dried legs) from 13 specimens were prepared for DNA barcoding, a method that usually allows accurate species identification from a 658-base-pair long segment of the COI gene. These samples were successfully processed at the Canadian Centre for DNA Barcoding (CCDB, Biodiversity Institute of Ontario, University of Guelph) to obtain DNA barcodes, using the standard high-throughput protocol described by deWaard et al. (2008). Additionally, 7 public sequences from BOLD (Ratnasingham and Hebert 2007; Ratnasingham 2018) were used as reference material for tree construction. Complete voucher data and images of these specimens are available in the public dataset [DS-Carcina] "*Carcina revision*" (https://doi.org/10.5883/ds-carcina).

Sequences were assigned to Barcode Index Numbers (BINs), algorithm-based operational taxonomic units that provide an accurate proxy for species (Ratnasingham and Hebert 2013). BINs were automatically calculated for records in BOLD that comply with the DNA Barcode standard. Degrees of intra- and interspecific variation in the DNA barcode fragments were calculated under the Kimura 2-parameter model of nucleotide substitution using the analytical tools of BOLD Systems v. 4.0 (http://www.boldsystems.org). The calculation of intraspecific distance was further normalized using BOLD's calculation tools to reduce sampling bias at the species level. A neighbor-joining tree of the DNA barcode data from the dataset was constructed using MEGA11 (Tamura et al. 2021) under the Kimura 2-parameter model for nucleotide substitutions.

Photographs of the adults were taken with a Zeiss Stemi 508 KMAT stereo microscope, genitalia photographs with a Zeiss Axiolab 5 microscope, both connected to an Olympus OM-D Mark III camera. Stacked photos were edited using Helicon Focus 4.8 and Adobe Photoshop 6.0.

Abbreviations of collections

TLMF Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria

ZMUC Zoological Museum, University of Copenhagen, Denmark

Results

Checklist of *Carcina*

***Carcina* Hübner**

Carcina Hübner, 1825; type species: *Tortrix fagana* Denis & Schiffermüller.

Phibalocera Stephens, 1829; type species: *Pyralis quercana* Fabricius.

Heterodmeta Meyrick, 1931, type species: *Heterodmeta homomorpha* Meyrick.

***Carcina quercana* (Fabricius, 1775) (*Pyralis*)**

= *Tortrix fagana* Denis & Schiffermüller, 1775.

= *Tinea cancella* Hübner, 1824.

= *Carcina quercana* var. *purpurana* Millière, 1874.

***Carcina ingridmariae* sp. nov.**

***Carcina luridella* (Christoph, 1882) (*Lecithocera*)**

= *Heterodmeta homomorpha* Meyrick, 1931.

***Carcina haemographa* Meyrick, 1937**

Remarks. *Pyralis quercana* was described from oak forests in Saxony (Fabricius 1775). The area is located in the range for the species known today under this name.

Tortrix fagana was described from eastern Austria (Vienna region) (Denis and Schiffermüller 1775). Also here, only *C. quercana* is known.

Tinea cancella was described without any indication of type locality and can therefore only be described with certainty as a European taxon (Hübner 1796–1836). The type material is considered lost. However, the precisely drawn original illustration undoubtedly shows a typical male of *C. quercana*.

Carcina quercana var. *purpurana* was described from the lowland areas of the Alpes Maritimes based on specimens with conspicuous purple forewings

(Millière 1871–1876). However, from several genitalia slides made by J. Nel and T. Varenne (in litt.) from this area as well as from material in TLMF such phenotypes are regularly found and differ neither in genitalia morphology nor genetically from nominotypical *C. quercana* (Pathpiva 2025).

Molecular analysis. The Neighbor-Joining tree produced is based on 14 DNA barcodes sequences, all with 658 bp, of *C. quercana* and five DNA barcode sequences of *C. ingridmariae* with 653 to 674 bp. A single short sequence from Crete with only 234 bp is not included in this analysis but fully corresponds with the new species. A DNA barcode sequence of *Odites kollarella* (Costa, 1832) (Peleopodidae) is considered as outgroup (Fig. 1).

Carcina ingridmariae clusters in it´s own and unique BIN: BOLD:ADY8382. The intraspecific average p-distance of the barcode region within this BIN based from BOLD data is 0.23%, the maximum distance is 0.64% (n = 8). The minimum distance to the Nearest Neighbor *C. quercana* is 6.55%.

Carcina quercana clusters in it´s own and unique BIN: BOLD:AAB0177. The intraspecific average p-distance in this species is 0.29%, the maximum distance is 2.13% (n = 178). The minimum distance to the Nearest Neighbor *C. ingridmariae* is 6.55%.

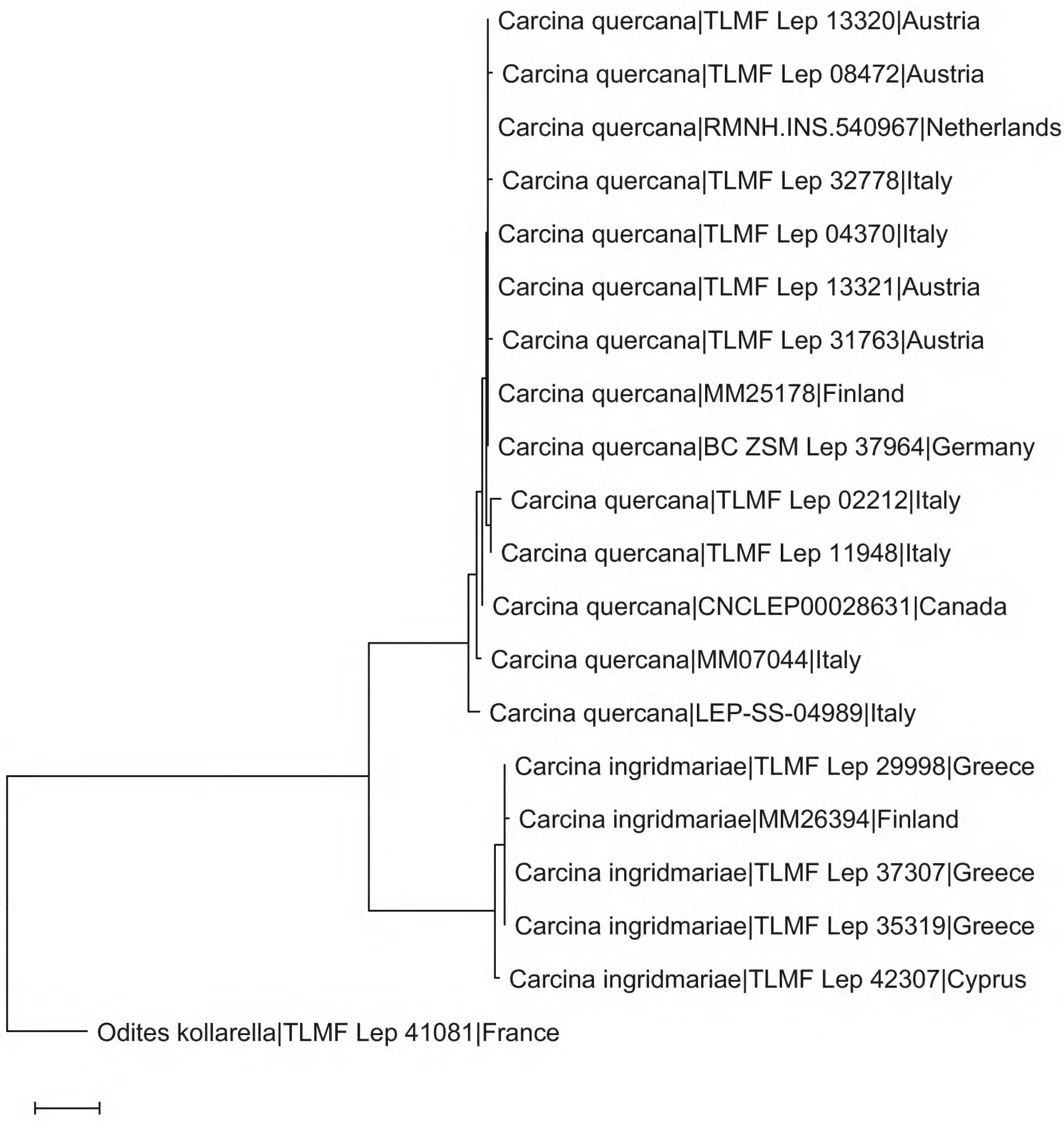


Figure 1. Neighbor-Joining tree of *Carcina* spp. (Kimura 2-parameter, built with MEGA11; Tamura et al. 2021), rooted for *Odites kollarella* as outgroup; source: DNA barcode data from BOLD, DS-CARCINA (Barcode of Life Database; Ratnasingham 2018).

***Carcina ingridmariae* sp. nov.**

https://zoobank.org/54B518A8-5452-4BF7-891D-A3A8B8C91847

Figs 2, 4, 6, 8, 10, 12, 14, 16, 18

Material examined. ***Holotype.*** Greece • ♂; Crete, Lakki, 4.2 km SSW; 650 m; 35°22'00"N, 23°54'52"E; 21 September 2022; leg. Huemer; DNA Barcode TLMF_Lep_35319; TLMF.

Paratypes. Greece • 1 ♂; Crete, Rethymnon, Agios Vasilios; 384 m; 35.234017°N, 24.414522°E; 13 September 2022; leg. K. Berggren; 1 ♂; same data but 396 m, 35.234867°N, 24.414050°E; 7 September 2023, leg. K. Berggren; 1 ♂; same data but 6, 7 May 2025; leg. K. Berggren, P. K. Slagsvoll, R. Voith; coll. Berggren • 1 ♂; Chania, Zounaki; 35.481792°N, 23.828388°E; 30 May – 13 June 2023; leg. K. Berggren & R. Voith; coll. Berggren • 1 ♂; Crete, N Lassithi, Mesa Lasithi; 850 m; 14 August 2006; leg. Ruckdeschel; DNA Barcode TLMF Lep 30434; TLMF • 3 ♂, 3 ♀; Peloponnese, Taygetos mts. E, Schlucht Stavros-Kalamata; 780 m; 37°04'46"N, 22°18'30"E; 21 September 2020; leg. Huemer; DNA Barcodes TLMF Lep 29998, TLMF_Lep_37307; gen. slide GEL 1378♀ P. Huemer; TLMF • 2 ♀; Peloponnese, above Pikoulionako/Mystras; 890 m; 38°06'11"N, 22°09'16"E; 22 September 2020; leg. Huemer; TLMF • 1 ♂, 1 ♀; Peloponnese, Chelmos mts., Zachlorou; 845 m; 37°04'58"N, 22°20'31"E; 27 September 2020, leg. Huemer; TLMF • 1 ♂; Peloponnese, Mount Kyllini; 1500 m; 37°56'51"N; 22°25'54"E; 2 June 2024; leg. P. Skou; ZMUC • 2 ♀; Chalkidiki, Olympias; 10 m; end June 1976; leg. Zürnbauer; gen. slide in glycerin capsule; TLMF • 1 ♂, 1 ♀; Kos, Asfedion; 6–12 October 1988; leg. R. Johansson; ZMUC. Croatia • 1 ♀; Krk, Umg. Punat, Konobe; 22 September 1993; leg. Habeler; gen. slide in glycerin capsule; TLMF; • 1 ♀; Krk, Stara Baska; 23 September 1989; leg. Habeler; TLMF. Cyprus • 1 ♂, 1 ♀; North Cyprus, Iskele, Kaplica, Kantara Castle; 550 m; 35°24'12"N, 33°55'02"E; 5 June 2024; leg. Huemer; gen. slides GEL 1367♂ P. Huemer, GEL 1369♀ P. Huemer; TLMF • 4 ♂, 3 ♀; same data, but 6 June 2025; leg. Huemer; TLMF; Cyprus Herbarium and Natural History Museum, Nicosia • 1 ♀; North Cyprus, Kyrenia, ca. 1 km E Ilgaz; 340 m; 35°19'16"N, 33°14'02"E; 2 June 2025; leg. Huemer; TLMF • 1 ♀; N Limassol, Moniatis; 850 m; 23–29 June 1997; leg. D. Nilsson, A. Madsen, M. Fibiger, P. Svendsen; ZMUC. Türkiye • 1 ♀; Prov. Baliksehir, Gönen; 15 m; 22 August 1978; leg. De Freina; ZMUC.

Diagnosis. The new species cannot be distinguished phenotypically from *C. quercana* with certainty (Figs 2–7). However, there is a clear tendency towards a reduction of markings of the forewings, especially in the males, and the ground color of the forewings is often more pale orange-brown and not red- to pink-brown. Furthermore, the yellow costal blotch of the forewing is usually more slender and yellow markings in the basal half of the forewing as well as dark markings of the forewing are reduced.

In contrast, the genital structures of both species differ significantly. *Carcina ingridmariae* males have a slender gnathos only about half as wide compared to that of *C. quercana*. They further differ by a very broad and long detached cucullus, more slender juxta lobes and, judging from the few specimens available so far, the absence of cornuti (Figs 8–13). In the female sex, the new species differs from *C. quercana* above all by the conspicuous, broadly tubular antrum (Figs 14–19).

The other congeneric taxa cannot be confused externally. Furthermore, *C. luridella*, which is somewhat similar in the male genitalia, differs particularly by the much broader gnathos (Ponomarenko and Chernikova 2018).

Description. Adult (Figs 2, 4, 6). Head pale orange-brown with beige frons; labial palpus long, upcurved, yellowish, with some purple on segment 3; antenna mixed yellow and orange-brown, very long, extending to about apex of forewing, segments broader in male than in female. Thorax and tegula pale orange-brown; legs beige, forelegs mixed with yellow and purple. Forewing length ♂ 8.0–9.3 mm, ♀ 7.6–10.5 mm; forewings broad with strongly convex costa; ground colour pale orange-brown to orange-pink; darker spots and small yellow spots in basal half sometimes present; costa with short yellow stripe at base and elongated blotch at about three-fifths, indistinct dark yellow and sometimes purple edge in-between; termen with purple edge and yellow fringes, interrupted by purple line at apex. Hindwings broad, with concave outer edge, distally slightly tapered, shorter than forewing, glossy beige, sometimes with purple apex, fringes yellow with or without purple tinge.

Variation. The ground color of the forewing and extension of yellow markings, darker spots and purple edging vary somewhat.

Male genitalia (Figs 8, 10, 12). Uncus basally broad, sub-triangular, short distal part abruptly tapered, rod-like; gnathos long, finger-shaped, about two-times length and width of distal part of uncus; valva basally broad, with distinctly separated cucullus and sacculus; long cucullus broadly thumb-shaped, basal two-fifths merged with valva, inner margin with suboval fold, remaining three-fifths separated, entire cucullus densely covered with microtrichia; sacculus well separated from valva by concave sclerotized edge, ventral margin convex, basal part covered with long setae, distal third finger-like, detached and about half as wide as cucullus, apex with brush of strong spines, nearly reaching apex of cucullus; juxta sub-oval with long and slender, evenly curved and apically pointed juxta lobe; saccus a weakly V-shaped sclerotized ridge; phallus stout, ventrally with plate-like sclerite, otherwise membranous, without cornuti.

Variation. The shape of the cucullus shows some variation, with a straight apical edge in two specimens from Crete. Similarly, the shape of the cucullus also varies considerably in *C. quercana* (Lepidoptera Dissection Group UK 2025; Pathpiva 2025).

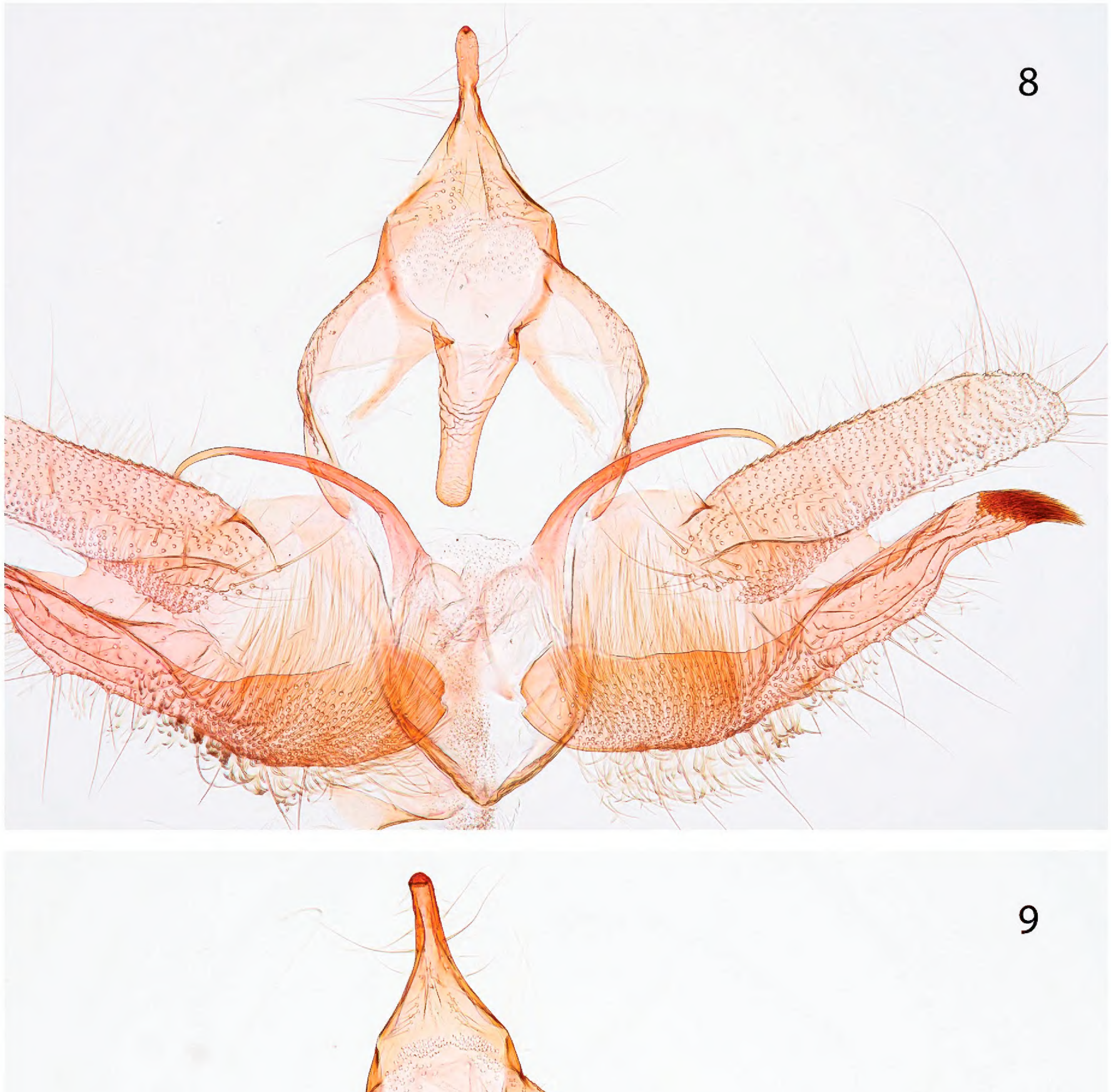
Female genitalia (Figs 14, 16, 18). Papillae anales elongated, suboval, covered with setae; posterior apophyses approximately twice as long as papillae anales and segment VIII; anterior apophyses 1.5 length of

Figures 2–7. Adults. **2.** *Carcina ingridmariae* sp. nov., paratype, male, Greece; **3.** *C. quercana*, male, Austria; **4.** *C. ingridmariae* sp. nov., paratype, female, Greece; **5.** *C. quercana*, female, Italy; **6.** *C. ingridmariae* sp. nov., paratype, female, Croatia; **7.** *C. quercana*, female, Greece. Scale bar: 10 mm.

segment VIII; tergite VIII smoothly sclerotized, posterior edge with strong bristles; sternite VIII laterоventrally with large suboval sclerotized areas, densely covered with microtrichia and strong bristles, medially separated by small sclerotized plate covered with some microtrichia, anterior part of sternite VIII membranous; antrum strongly sclerotized, broadly tube-shaped, about as long as sclerotized part of segment VIII; ductus bursae short and broad, contorted; corpus bursae about as long as segment VIII and posterior apophyses, sack-like, with or without small dentate signum.

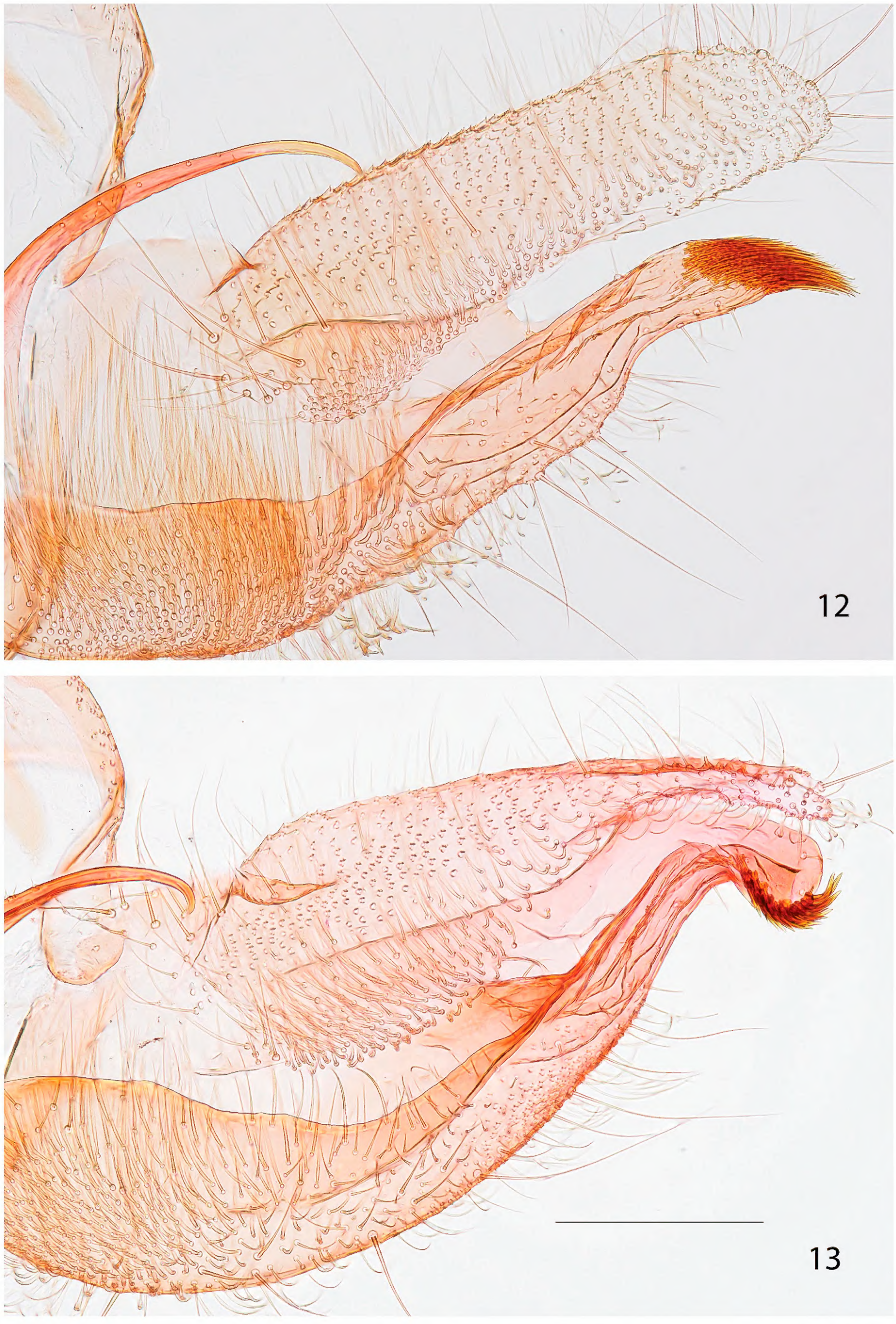
Variation. A small signum is present in females from Croatia and Greece (Chalkidiki and Peloponnese), but absent in a specimen from Cyprus.

Biology. The biology has not been described, but extensive data on larval phenology and food plant spectrum of alleged *C. quercana* from Greece (Mt. Cholomontas, Chalkidiki) refer with high probability to the new species,



Figures 8, 9. Male genitalia. **8.** *Carcina ingridmariae* sp. nov., paratype, Cyprus, slide GEL 1367 P. Huemer; **9.** *C. quercana*, Austria, GEL 1366 P. Huemer. Scale bar: 0.5 mm.

Figures 10, 11. Male genitalia, details (gnathos, juxta lobes). **10.** *Carcina ingridmariae* sp. nov., paratype, Cyprus, slide GEL 1367 P. Huemer; **11.** *C. quercana*, Austria, GEL 1366 P. Huemer. Scale bar: 0.2 mm.



Figures 12, 13. Male genitalia, details (cucullus, sacculus). **12.** *Carcina ingridmariae* sp. nov., paratype, Cyprus, slide GEL 1367 P. Huemer; **13.** *C. quercana*, Austria, GEL 1366 P. Huemer. Scale bar: 0.2 mm.

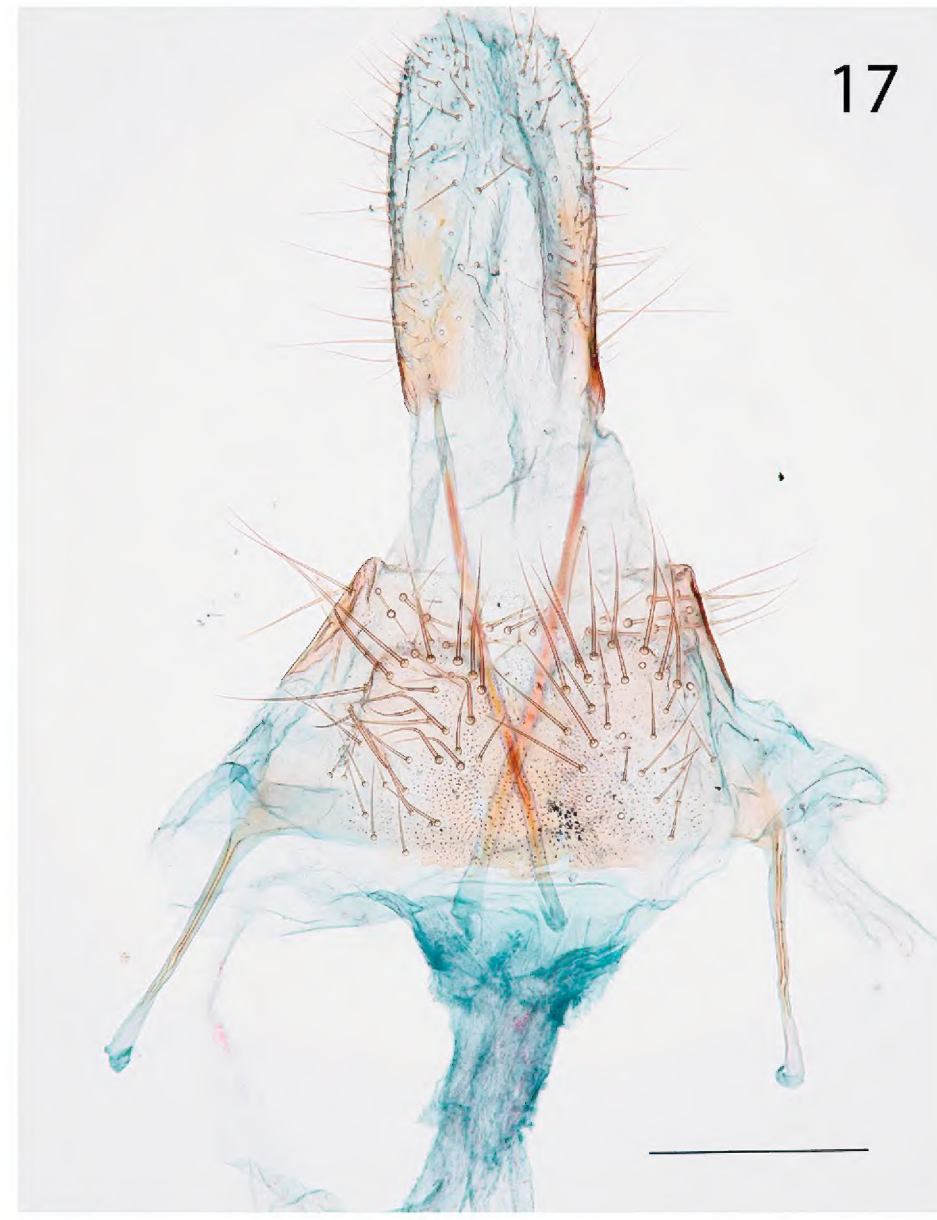
Figures 14, 15. Female genitalia. **14.** *Carcina ingridmariae* sp. nov., paratype, Cyprus, slide GEL 1369 P. Huemer; **15.** *C. quercana*, Austria, GEL 1368 P. Huemer. Scale bar: 0.2 mm.

as part of the type material was collected on Chalkidiki. Accordingly, *C. ingridmariae* would live on all oak species examined in the area, with evidence on *Quercus trojana*, *Q. pedunculiflora*, *Q. macrolepis*, *Q. coccifera*, *Q. ilex*, *Q. pubescens*, *Q. dalechampii* and *Q. frainetto* (Kalapanida and Petrakis 2012). However, like *C. quercana*, the species probably feeds on a wider range of woody plants, which is also indicated by the findings of *C. ingridmariae* in north Cyprus, where *Quercus* species are absent.

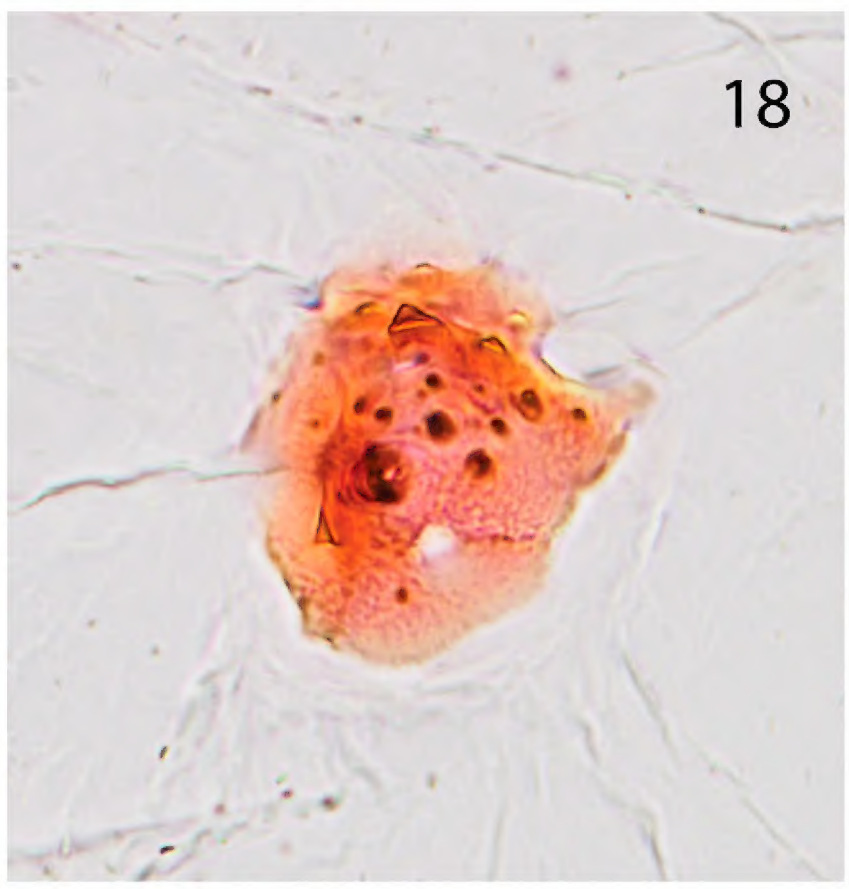
Although no information is known about the caterpillar's habits, it can be assumed that, like *C. quercana*, they live in a flat, silvery white, protective silk web on the underside of the leaves of the host plant. In *C. quercana*, pupation takes place between two spun leaves (Sterling and Parsons 2012; Schmid 2019).

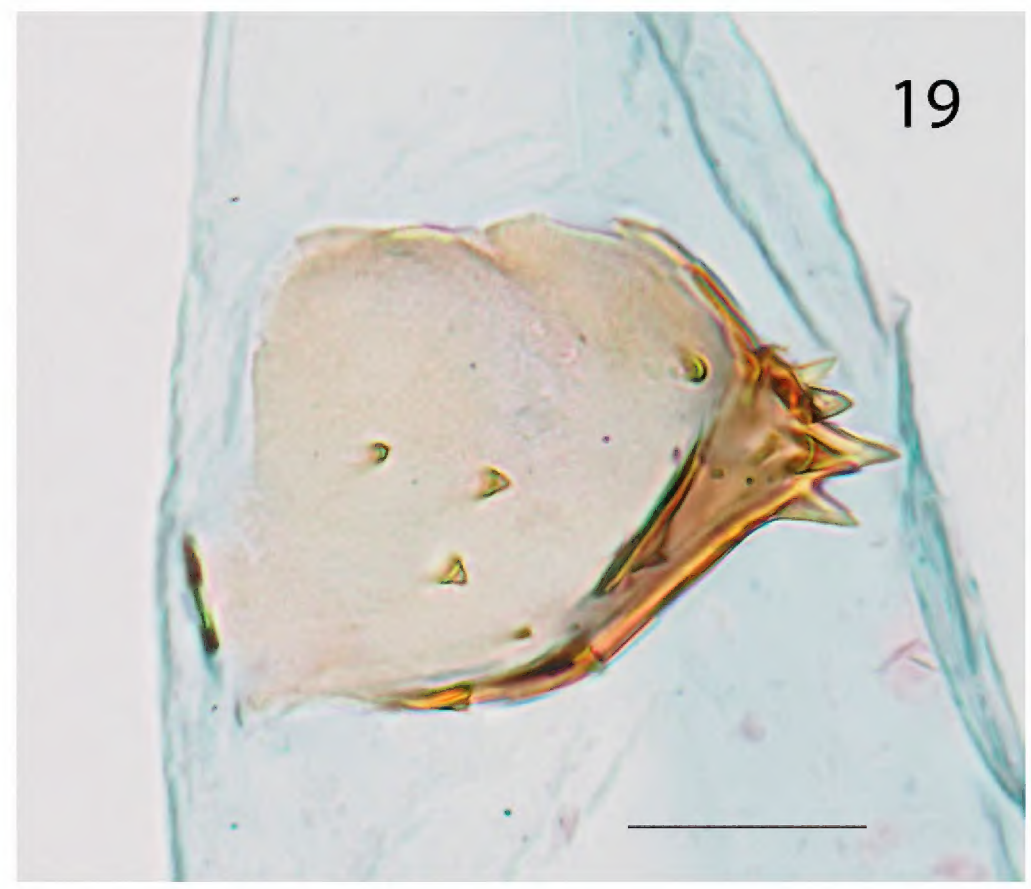
The new species has been recorded in various wooded or shrub-rich habitats from lowland to mountain areas from the coastline to ca. 1500 m at artificial light, but details on ecology are lacking (Fig. 20). According to available data, the flight period extends from early May to the end of June and from mid-August to the first half of October, indicating possible bivoltinism.

Distribution. Examined material: Greece (Chalkidiki, Peloponnese, Crete, Kos), Croatia, Cyprus, Türkiye. Following data in BOLD the species also occurs in Lebanon, indicating a wider distribution in the eastern Mediterranean.



Figures 16, 17. Female genitalia, details (Segment VIII, antrum). **16.** *Carcina ingridmariae* sp. nov., paratype, Cyprus, slide GEL 1369 P. Huemer; **17.** *C. quercana*, Austria, GEL 1368 P. Huemer. Scale bar: 0.2 mm.





Figures 18, 19. Female genitalia, details (signum). **18.** *Carcina ingridmariae* sp. nov., paratype, Greece, slide GEL 1378 P. Huemer; **19.** *C. quercana*, Austria, GEL 1368 P. Huemer. Scale bar: 0.03 mm.

Reports of *C. quercana* from Israel likely also belong to the new species (Lvovsky et al. 2016). The collecting locality of a barcoded specimen from Finland is uncertain (Mutanen in litt.) and from a biogeographical point of view an occurrence in Fennoscandia also seems highly unlikely.

In contrast, *C. quercana* is widespread in large parts of Europe and confirmed records examined in this study are also available for North Africa. The southeastern distribution limit of this species, however, is unclear. Verified records of *C. quercana* from northern Greece (Epirus) and Croatia prove the occurrence in the Balkan. Findings from Türkiye probably all refer to *C. ingridmariae* (iNaturalist 2025). Similarly, records from Georgia and Azerbaijan may refer to the new species (Lvovsky 2003).

Figure 20. Habitat of *Carcina ingridmariae* sp. nov. in north Cyprus (eastern part of Five Finger Mountains near Kantara).

Records of *C. quercana* from North America are of recent origin and based on introduction.

Etymology. The new is dedicated to my wife Ingrid Maria, who for so many years accompanied and supported me during field work and long hours of analysis in the laboratory.

Discussion

Genetic methods, especially DNA barcoding, have led to numerous new discoveries in the European lepidopteran fauna in recent years. In most cases, however, these are rather inconspicuous and morphologically cryptic species that are more difficult to differentiate morphologically than by genetic sequences. Examples can be found in various families (Huemer and Hebert 2012; Huemer and Mutanen 2015; Gregersen and Karsholt 2017; Zlatkov and Huemer 2017; Ronkay and Huemer 2018; Huemer 2020, 2024; Huemer and Karsholt 2020; Huemer et al. 2020; Berggren et al. 2022; Voith et al. 2023; Buchner and Corley 2024; Kovács et al. 2024; Nel et al. 2024). In contrast, only a few externally distinctive species were newly discovered, especially in peripheral areas such as Mediterranean islands (Aarvik et al. 2023; Berggren and Aarvik 2024; Huemer et al. 2025) and the Canary Islands (Falck and Karsholt 2025; Tabell et al. 2025), rarely in Central Europe (Šumpich and Huemer 2016), or species flying off-season (Hausmann et al. 2023).

Only in a few exceptional cases more widespread but conspicuous species have been discovered, i.e. *Pyralis cardinalis* (Wikström et al. 2020). The new species described here was also wrongly attributed to an apparently unmistakable species. The oldest currently known specimen was published by Rebel (1916) and type material sampled as early as 1978 was integrated into collections without detailed morphological investigation. Only efforts to create barcode libraries that were as complete as possible for south-eastern Europe and the extensive sequences already available from other regions ultimately led to the discovery of the problem. It can be assumed that several genetically divergent clusters, i.e. recently discovered in Crete or Cyprus, contain further cryptic diversity (Huemer and Özden 2024; Huemer et al. 2025).

Even a reasonably complete survey of European species diversity will only be possible through a consistent genetic survey of all taxonomic groups with the broadest possible geographical coverage across the entire continent. Such work is currently only available in isolated cases for larger taxonomic groups (Skou et al. 2015; Müller et al 2019; Huemer et al. 2020; Dincă et al. 2021; Lopez-Vaamonde et al. 2021).

Acknowledgements

I am most grateful to Paul Hebert and his team at the Centre for Biodiversity Genomics (Guelph, Canada), whose sequencing support and the BOLD informatics was enabled by funding from the Canada Foundation for Innovation, by Genome Canada through Ontario Genomics, and by the Tri-Council's New Frontiers in Research Fund. I would also like to thank Kai Berggren, Ole Karsholt, Jacques Nel, Özge Özden, Thierry Varenne and Walter Ruckdeschel for important loans, donations and information. Finally, thanks are expressed to the nature conservation authorities in Greece and Northern Cyprus for issuing collecting permits.

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